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London, England
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[33] **Australia**
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[54] **OSCILLATOR OUTPUT CIRCUIT CONFIGURATION**
11 Claims, 2 Drawing Figs.

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[51] **Int. Cl.** **H02m 3/32,**
A610n
[50] **Field of Search** 321/2, 16;
128/422, 423, 21; 331/112; 315/221, 225, 135, 129

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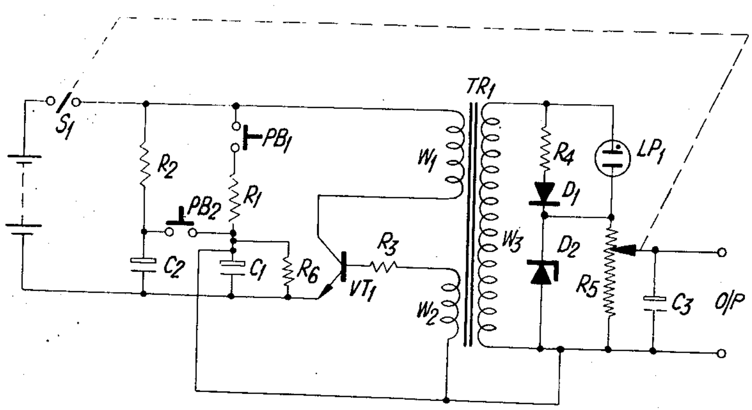
ABSTRACT: A circuit configuration and an electronic locator/stimulator device for medical purposes incorporating said circuit configuration in which a first pulse component of an output signal, which is clipped to a predetermined voltage amplitude, is impressed across load terminals of the circuit while a second pulse component of the output signal appears across a gas discharge indicator lamp.



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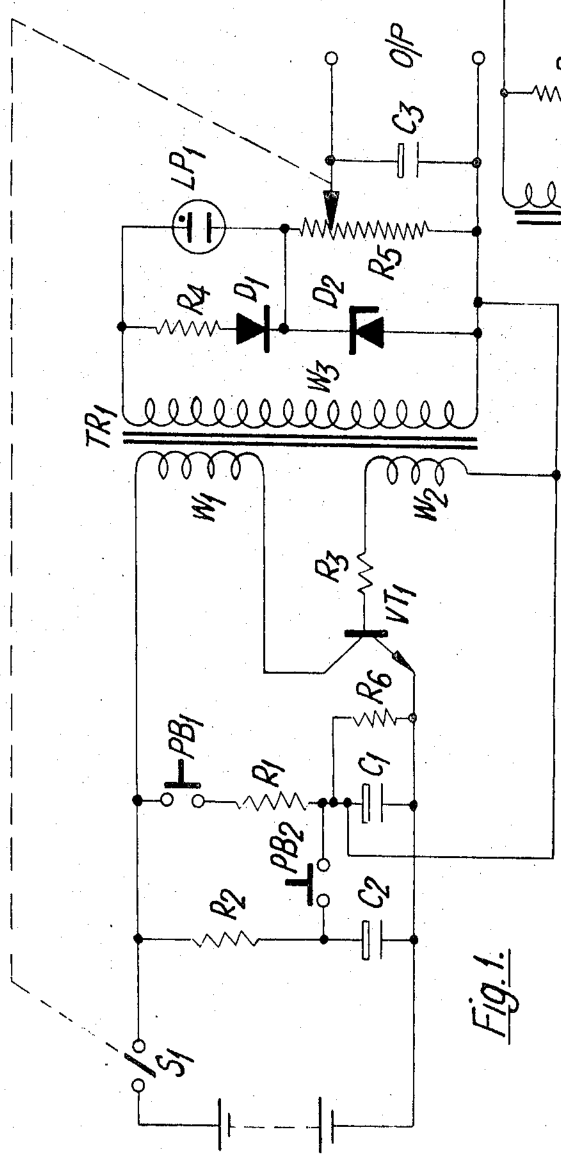

Fig.1.

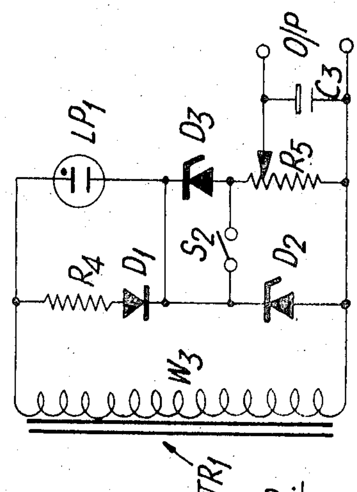

Fig.2.

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OSCILLATOR OUTPUT CIRCUIT CONFIGURATION

This invention relates to an improved electronic oscillator circuit and, more particularly, to an output circuit configuration for such oscillator.

The invention also relates to an electronic nerve locator/stimulator which embodies an oscillator incorporating said output circuit configuration.

The purpose of an electronic nerve locator/stimulator is, inter alia, to locate (by the use of suitable needle electrodes) the position of a particular nerve which is disposed below the skin and tissue of a patient, and to identify that nerve (by the application of electrical stimulus) so that, by the adoption of nerve block procedures, the nerve may be rendered inoperative. Another purpose of the locator/stimulator is to locate and identify (by electrical stimulation a nerve which has been exposed during surgery.

For the above purposes, the locator/stimulator should be capable of producing:

a. pulses in a "Tetanus" mode, at a rate of approximately 30 pulses per second,

b. pulses in a "Normal" mode, at a rate of one pulse per 2 seconds—(the initial pulse in this mode should, for the convenience of an anaesthetist, occur at the instant of selection in order to permit "single shot" operation),

c. an output voltage existing over the approximate range of to at least **30** volts to permit sensitive and accurate location of a particular nerve,

d. an output pulse (or pulses) of square waveform having a fast rise time, no overshoot and a width sufficient to overcome any existing indirect blockage of a neuromuscular junction; and

e. a visible indication of individual pulse outputs.

The actual desired pulse repetition rate, pulse size and pulse shape are all functions of the oscillator circuit configuration and may be obtained by the use of an oscillator of the general type described in the applicant's copending application No. 32043/68. However, as above mentioned, it is desirable that visual indication be give at each pulse output and (by virtue of a necessity for power economy) this presupposes the provision of a gas discharge lamp, which requires a comparatively high operating voltage. Also, as above mentioned the output should be a square wave of comparatively low voltage. These, apparently, incompatible requirements are met by the provision of an output circuit configuration as below defined.

Thus, the present invention provides an oscillator in circuit with a power supply and a primary winding of a transformer, and an output circuit connected across a secondary winding of said transformer; said output circuit comprising a gas discharge lamp connected across said secondary winding and in series with a pair of load terminals, a forward conducting rectifier means connected across said gas discharge lamp, and a reference voltage rectifier means reverse connected in circuit with the first-mentioned rectifier means and across said load terminals.

The invention further provides an electronic nerve locator/stimulator comprising a power supply, a transistorized oscillator circuit including at least one transistor in circuit with a resistance-capacitance timing network, the effective impedance of which is variable to provide a desired output pulse repetition rate, a transformer having a primary winding or windings in circuit with said oscillator, and an output circuit from which an output pulse may be obtained connected across a secondary winding of the transformer; said output circuit comprising a gas discharge lamp connected across said secondary winding and in series with a pair of load terminals, a forward conducting rectifier means connected across said gas discharge lamp, and a reference voltage rectifier means reverse connected in circuit with the first-mentioned rectifier means and across said load terminals.

There is more particularly provided in accordance with the present invention a nerve locator/stimulator comprising a power supply, an oscillator circuit including a single transistor in circuit with a resistance capacitance timing network, the effective impedance of which is variable to provide a desired output pulse repetition rate, a transformer, said transformer having a first primary winding in circuit with the collector of the transistor and a second primary winding in circuit with the base of the transistor and through which a reflected current is passed by way of a positive feedback loop to said transistor base; and an output circuit from which an output pulse may be obtained connected across a secondary winding of the transformer, said output circuit comprising a gas discharge lamp connected across said secondary winding and in series with a pair of load terminals, a forward conducting diode connected across said gas discharge lamp, and a zener diode reverse connected in circuit with the first mentioned diode and across said load terminals, whereby a first pulse component of the output signal will appear across said load terminals, the voltage level of the output pulse being limited by the breakdown voltage of the zener diode, and a second pulse component of the output signal will appear across said gas discharge lamp.

The invention will be more fully understood from the following description of a preferred embodiment thereof taken in conjunction with the accompanying drawing.

In the drawing

FIG. 1 shows a circuit diagram of a nerve locator/stimulator device and

FIG. 2 shows a modified output circuit arrangement for the device of FIG. 1.

From the drawing, the device generally comprises a power supply, an oscillator circuit employing a single transistor VT_1 in conjunction with a pulse transformer TR_1 the pulse repetition rate of which is controlled by an R-C network, and an output circuit connected to the secondary winding of the transformer.

The fundamental operation of the circuit is based on a modified "blocking oscillator." The timing capacitor C_1 (or capacitor network C_1+C_2) initially has zero voltage across it but charges through the timing resistor R_1 (or resistor network R_1+R_2) until such time as the voltage across C_1 (or C_1+C_2) exceeds the base-emitter forward conduction voltage of the transistor VT_1. The transistor base then conducts and collector current is drawn through the winding W_1 of the transformer TR_1. The current through winding W_1 is reflected into winding W_2 and, through positive feedback, turns the transistor "on" hard. This gives a short rise time to the base, and therefore collector current pulse.

The additional base bias supplied from the reflected pulse permits the base current to discharge the capacitor C_1 (or C_1+C_2) to a very low level. Base current is desirably limited to a safe value by introduction of a series limiting resistor R_3.

After the pulse from the collector circuit has decayed, transistor VT_1 is cut off, since the voltage across C_1 (or C_1+C_2) again approaches zero, and the circuit can no longer ring. One pulse only is thus initially generated.

The cycle then repeats as the capacitor network charges through the resistance network, a train of single pulses being generated by the circuit for as long as the power supply is "-switched on," in this case by switch S_1 ganged to potentiometer R_5, hereinafter referred to.

The pulse repetition rate is dependent upon the time constant of the R.C. network, this, as shown in the drawing, being made variable by the capacitor switching arrangement comprising pushbuttons PB_1 and PB_2.

On operation, depressing pushbuttons PB_1 permits capacitor C_1 to charge through resistor R_1 until the firing point of the transistor is reached. By holding the pushbutton in the depressed position a pulse repetition rate proportional to the time constant of the R_1–C_1 network will be maintained.

Then, by depressing pushbutton PB_2, capacitor C_2, by being connected across the battery through resistor R_2 is in a charged condition, shares its charge with capacitor C_1 and raises the voltage sufficiently to cause the transistor VT_1 to fire instantaneously. The transistor will then continue to fire at a repetition rate determined by the time constant of the $R_2.(C_1+C_2)$ network for as long as pushbutton PB_2 is kept depressed. Capacitor C_2 however has a very small value (in the order of 1 percent) compared with that of C_1 and this thus provides an effective time constant (with PB_2 depressed) of $R_2.C_1$.

Since capacitor C_2 will charge rapidly through resistor R_2 when pushbutton PB_2 is released, repetitive operation of pushbutton PB_2 will result in single pulses responsive to each depression. The circuit thus combines the function of "single shot" and repetitive pulsing.

To facilitate improved operation of the circuit above described, a resistor R_6 is shunted across capacitor C_1 to stabilize the firing point of transistor VT_1 and to compensate for variation in the capacitance of capacitor C_1.

The collector current pulse in winding W_1 is also reflected into the secondary winding W_3 and across which a high voltage pulse is developed, the value of which is determined by the primary to secondary winding ratio and which will be sufficient to cause a gas discharge lamp LP_1 to light.

With reference now to the input circuit of FIG. 1; during the initial positive portion of the transformer output pulse (which preferably has a square waveform) diode D_1 conducts and the whole of the pulse appears across the voltage control potentiometer R_5, which is in parallel with a zener diode D_2. Zener diode D_2 is selected to break down in the zener mode at a desired upper voltage level and a resistor R_4 is inserted in series with both diodes to act as a current limiter. Thus, the voltage across potentiometer R_5 is limited to the breakdown voltage of diode D_2 and is clipped as a square wave. Also, since the voltage across D_1 and R_4 will be low, the gas discharge lamp LP_1 will not light. Then, during the negative portion of the pulse, diode D_2 will conduct in the forward direction whilst diode D_1 "blocks" such that a small voltage appears across potentiometer R_5, and the majority of the pulse appears across the lamp LP_1. By this means, a square pulse is obtained out the output terminals and, at the same time, the lamp is ignited during each successive pulse.

With reference to FIG. 2, there is shown an output circuit configuration which permits the selection of either one of two output voltages. In this case a further zener diode D_3 is inserted in series with the diode D_1 and the potentiometer R_5, the diode D_3 being adapted to be shorted out by a switch S_2.

When diode D_3 is shorted by the switch S_2, the output voltage is that of diode D_2, as above. However, when the switch S_2 is opened, the output voltage will be a difference voltage between the two zener diodes ($V_{D2}-V_{D3}$). Any small "-switching" spikes which may occur with this configuration may be eliminated by connecting capacitor C_3 across the output terminals.

Many modifications may be made in the circuit as described above and as illustrated without departing from the scope of the invention. However, the following are given by way of exemplification as components and component values which may be employed to construct such a device, the elements referred to being those shown in FIG. 1 of the drawing:

Battery,	6-volt (4×1.5 volt pencil cells)
Resistor R_1,	2.2 K ohms
Resistor R_2,	120 K ohms
Resistor R_3,	22 ohms
Resistor R_4,	2.2 K ohms
Potentiometer R_5,	25 K ohms, linear
Resistor R_6,	100 K ohms
Capacitor C_1,	200 microfarads
Capacitor C_2,	2 microfarads
Capacitor C_3,	470 picofarads
Diode D_1,	BY 126
Diode D_2,	IN 972
Transistor VT_1,	Silicon NPN type AS310
Transformer TR_1,	"Ferguson" type TSW112

With the various discussed compounds having values as above indicated, the following results have been found obtainable:

a. Output voltage	0 to 30 volts (max.)
b. Pulse width	4 milliSecs. (max.)
c. Pulse energy	0.8 milliJoules (max.)
d. Pulse repetition rate	30 pulses/second (PB_1 depressed) 1 pulse/2 seconds (PB_2 depressed)

By selecting an appropriate zener diode D_3, a desired output voltage scale range may be achieved. For example, if diode D_3 was selected to break down in the zener mode at 24 volts, with switch S_2 opened a maximum output voltage of (30–24)=6 may be obtained.

A container for the components afore described may be formed of any suitable plastic material, the cover therefore being apertured to permit the mounting or external projection of the lamp LP_1, switch S_2, pushbuttons PB_1 and PB_2 and a control knob for the ganged potentiometer/switch S_1. The cover may additionally be marked with suitable indicia and the container apertured to take a connectable probe or electrode lead plug.

Electrodes for use in conjunction with the device above described may take the form of needle electrodes or probes.

What is claimed is:

1. An oscillator in circuit with a power supply and a primary winding of a transformer, and an output circuit connected across a secondary winding of said transformer; said output circuit comprising a gas discharge lamp connected across said secondary winding and in series with a pair of load terminals, a forward conducting rectifier means connected across said gas discharge lamp, and a reference voltage rectifier means reverse connected in circuit with the first-mentioned rectifier means and across said load terminals.

2. In a circuit configuration comprising an oscillator in circuit with a power supply and a primary winding of a transformer, and an output circuit connected across a secondary winding of said transformer; said output circuit comprising a gas discharge lamp connected across said secondary winding and in series with a pair of load terminals, a forward conducting diode connected across said gas discharge lamp, and a zener diode reverse connected in circuit with the first-mentioned diode and across said load terminals, whereby a first pulse component of the output signal appears across said load terminals, the voltage level of the output pulse being limited by the breakdown voltage of the zener diode, and a second pulse component of the output signal appears across said gas discharge lamp.

3. The circuit configuration as claimed in claim 2 including a second zener diode connected in series through a switching device with the first-mentioned zener diode whereby the output pulse voltage level is, with the switch open, a difference voltage between that of the first and second zener diodes.

4. The circuit configuration as claimed in claim 2 including a linear voltage control potentiometer connected across said load terminals.

5. The circuit configuration as claimed in claim 2 wherein the output pulse is clipped by the zener diode as an approximately square wave.

6. A nerve locator/stimulator comprising a power supply, a transistorized oscillator circuit including at least one transistor in circuit with a resistance-capacitance timing network, the effect impedance of which is variable to provide a selected output pulse repetition rate, a transformer having at least one primary winding in circuit with said oscillator, and an output circuit from which an output pulse is obtained connected across a secondary winding of the transformer; said output circuit comprising a gas discharge lamp connected across said secondary winding and in series with a pair of load terminals, a forward conducting rectifier means connected across said gas discharge lamp, and a reference voltage rectifier means reverse connected in circuit with the first-mentioned rectifier means and across said load terminals.

7. A nerve locator/stimulator comprising a power supply; an oscillator circuit including a single transistor in circuit with a resistance capacitance timing network, the effective impedance of which is variable to provide a selected output pulse repetition rate; a transformer, said transformer having a first

primary winding in circuit with the collector of the transistor and a second primary winding in circuit with the base of the transistor, and through which a reflected current is passed by way of a positive feedback loop to said transistor base; and an output circuit from which an output pulse is obtained connected across a secondary winding of the transformer, said output circuit comprising a gas discharge lamp connected across said secondary winding an in series with a pair of load terminals, a forward conducting diode connected across said gas discharge lamp, and a zener diode reverse connected in circuit with the first-mentioned diode and across said load terminals, whereby a first pulse component of the output signal appears across said load terminals, the voltage level of the output pulse being limited by the breakdown voltage of the zener diode, and a second pulse component of the output signal appears across said gas discharge lamp.

8. A nerve locator/stimulator as claimed in claim 7 wherein there is a second zener diode connected in series, through a

switching device, with the first mentioned zener diode whereby the output pulse voltage level is selectable at two levels, said voltage level being, with the switch open, a difference voltage between that of the first and second zener diodes.

9. A nerve locator/stimulator as claimed in claim 7 wherein there is a linear voltage control potentiometer connected across said load terminals.

10. A nerve locator/stimulator as claimed in claim 7 wherein said output pulse is clipped by the zener diode as an approximately square wave.

11. A nerve locator/stimulator as claimed in claim 7 wherein the impedance value of said timing network is variable by switching at least one capacitor component thereof into or out of circuit with the base-emitter electrodes of the transistor.

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Disclaimer

3,624,484.—*John E. Colyer*, Longueville, New South Wales, Australia. OSCILLATOR OUTPUT CIRCUIT CONFIGURATION. Patent dated Nov. 30, 1971. Disclaimer filed Apr. 21, 1978, by the assignee, *Burroughs Wellcome Co.*

Hereby enters this disclaimer to all claims of said patent.

[*Official Gazette June 13, 1978.*]